

C L A I M S

1. A steerable soil penetration system, the system comprising:

- a steerable penetration head which is connected to an elongate flexible tubing such that the orientation of the penetration head can be varied relative to the tubing;
5 and

- means for injecting the elongate flexible tubing into the hole pierced by the penetration head and for inducing the penetration head to pierce the hole in a desired
10 direction; characterised in that the steerable penetration head is configured to penetrate the soil by compacting the soil without the action of rotating cutters.

2. The steerable soil penetration system of claim 1,
15 wherein the means for injecting the penetration head into the hole comprises a tubing injector assembly which pushes the tubing into the pierced hole thereby providing thrust to the penetration head, and wherein the tubing has an outer diameter which is more than 80% of the
20 largest outer width of the steerable penetration head.

3. The steerable soil penetration system of claim 1,
wherein the system is provided with a pump for pumping lubricating fluid through the interior of the tubing and an annular space between the tubing and the surrounding
25 soil.

4. The steerable soil penetration system of claim 1,
wherein the tubing is provided with conduits, electrical cables and/or optical fibres for the supply of power and/or for data communication and/or for measuring

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stresses along at least a substantial part of the length of the tubing.

5 5. The steerable soil penetration system of claim 1, wherein the steerable penetration head is provided with a repetitive shock generating device for enhancing the penetration of the penetration head through the soil, which device is optionally configured to vibrate the penetration head in axial and radial directions in order to reduce friction and compact surrounding soil.

10 6. The steerable soil penetration system of claim 5, wherein the repetitive shock generating device is actuated by an electrical actuator which is connected to an electrical source via an electrical conductor which extends through the interior or the wall of the tubing.

15 7. The steerable soil penetration system of claim 1, wherein the steerable penetration head comprises a sensor for detecting obstacles ahead of the penetration head which sensor is connected to a steering mechanism which is configured to change the orientation of the penetration head relative to the tubing such that the penetration head follows a curved trajectory to avoid detected obstacles.

20 8. The steerable soil penetration system of claim 7, wherein the steering mechanism is programmed to steer the penetration head along a predetermined trajectory through the soil and to return to said predetermined trajectory after the penetration head has deviated from said trajectory to avoid a detected obstacle.

25 9. The steerable soil penetration system of claim 1, wherein the steerable penetration head comprises a tapered nose section having a central axis that can be pivoted in any direction relative to a longitudinal axis of the tubing by the steering mechanism.

10. The steerable soil penetration system of claim 1,
wherein the penetration head is connected to the tubing
by a bendable tubular steering section which can be
induced by the steering mechanism to alternately obtain
a straight or a curved shape.

11. The steerable soil penetration system of claim 10,
wherein the bendable tubular steering section comprises
memory metal or bimetallic components and one or more
heating elements that are configured to vary the
temperature of said components such that the bendable
tubular section either obtains a straight or a curved
shape.

12. The steerable soil penetration system of claim 10 or
11, wherein the bendable tubular steering section
comprises at least three circumferentially spaced
segments, which segments can be individually heated or
cooled such that the lengths of the segments will vary
and that the bendable tubular section either obtains a
straight shape or becomes curved in any predetermined
orientation.

13. The steerable soil penetration system of claim 10,
wherein the bendable tubular steering section is at one
side weakened by perforations, slits or otherwise such
that it will bend in a predetermined direction under the
axial compression force exerted by the elongate flexible
tubing and wherein a stiff sleeve is movably arranged
adjacent to the bendable tubular section such that the
sleeve can be moved within or around the bendable tubular
section to force the section into a substantially
straight position and which can be retrieved from the
bendable tubular to induce the bendable tubular section
to bend under the axial compression force exerted by the
elongate flexible tubing.

14. The steerable soil penetration system of claim 1, wherein at least a substantial part of the elongate flexible tubing is configured to be circumferentially expanded after completion of the hole penetration process.

15. The steerable soil penetration system of claim 14, wherein the elongate flexible tubing is equipped with a staggered pattern of relatively weak wall segments that are configured to widen or open up during the circumferential expansion process, thereby reducing the forces required to circumferentially expand the tubing.

16. A method of piercing an at least partially horizontal or inclined hole in a subsurface formation with a steerable soil penetration system comprising a steerable penetration head, wherein a thrust force is exerted to the steerable penetration head by an elongate flexible tubing and/or downhole propulsion means, thereby inducing the penetration head to pierce the hole in a desired direction; characterised in that the penetration head is configured to compact soil adjacent to the penetration head substantially without the action of rotating cutters.

17. The method of claim 16, wherein at least part of said thrust force is exerted on the penetration head by pushing the elongate flexible tubing into the pierced hole and the tubing has an outer diameter which is more than 80% of the largest outer width of the steerable penetration head and/or of the hole being pierced thereby.

18. The method of claim 16, wherein at least part of said thrust force is applied to the steerable penetration head by downhole propulsion means which comprises a downhole shock generator which hammers the penetration head

forward through the subsurface formation during at least a final part of the hole piercing process.

19. The method of claim 17, whereby an electrical voltage is applied between the flexible tubing and the hole in such a way that polarization of any clay particles in the wall of the hole reduces any tubing-to-wall sticking tendency and decreases tubing-to-wall friction.

20. The method of claim 17, wherein at least part of the elongate flexible tubing is left behind in the pierced hole to serve a hole liner.

21. The method of claim 20, wherein at least part of the elongate flexible tubing is circumferentially expanded after completion of the piercing process such that the expanding tubing radially expands the pierced hole to a larger internal width.

22. The method of claim 21, wherein at least part of the elongate flexible tubing is circumferentially expanded by an expansion device which comprises an expansion cone and/or rollers that increase the internal width of the tubing when the device is moved in a longitudinal direction through the tubing and which expansion device simultaneously pulls one or more electric, fibre optical, fluid transportation and/or other conduits into the expanded section of the hole.

23. The method of any one of claims 16-22, wherein a string of geophones and/or fibre optical sensing devices is inserted into the pierced hole to monitor seismic reflections and/or other geophysical effects during an extensive period of time.

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